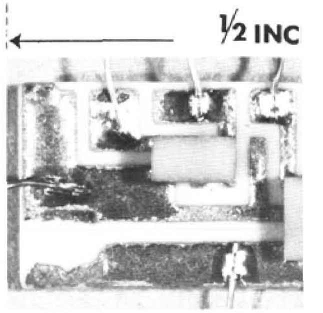
CL#09-0041

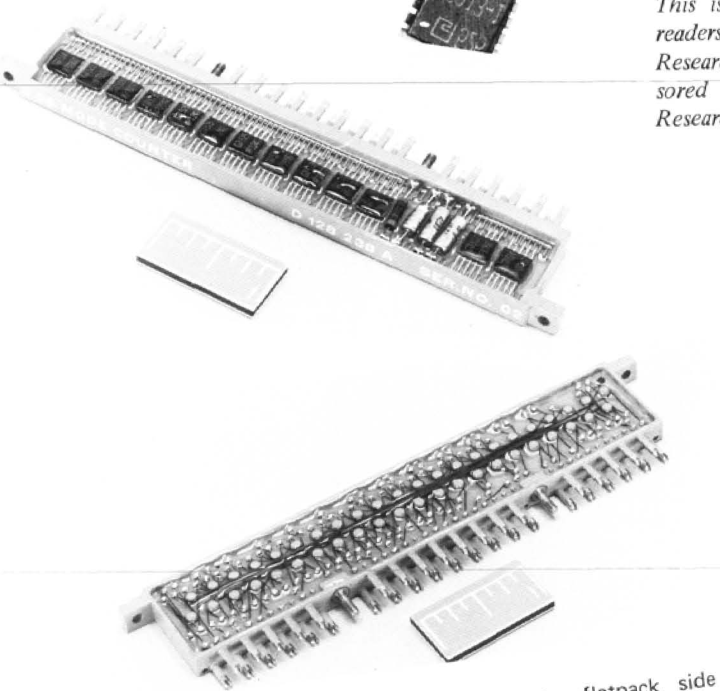
Electronic PACKAGING

A "flatpack".



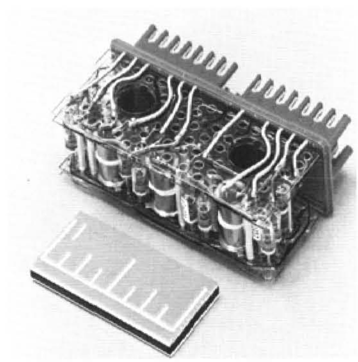
Typical hybrid confi
thick film substrate
chips.

This is another in a series of articles to acquaint readers of "Lab-Oratory" with activities in the JPL Research and Advanced Development Program sponsored by NASA and directed by the Office of Research and Advanced Development.



The "stick" package showing the flatpack side (above) and the wiring side (below).

"WIRECON" Module showing cordwood packaging of discreet electronic components.



Some of the welding equipment in the Microjoining Laboratory.

"Packaging" means many things to many people. To some, it's putting groceries in a box at the corner store; to others, like the personnel in Section 357 Electronic Packaging and Cabling, it means the design, assembling and interconnection of complex electronic components into subsystems.

Such subsystems have flown in all JPL spacecraft.

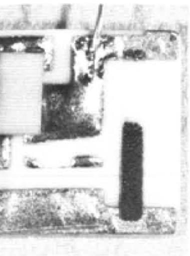
Because the electronic circuits are becoming smaller and more complex all the time, the problem of interconnecting becomes greater. A good example is the thimble which holds over 8000 (you may count them if you wish) integrated circuit chips, each one containing several transistors, resistors, diodes and other components. In order for these chips to function in a useful device they must be mounted and interconnected – or in other words, "packaged and cabled."

The problem: starting out with a thimble full of chips, or about 20,000 to 30,000 chips per cubic inch, by the time humans with their big fingers run wires between the chips to obtain a functioning system (computer or other) the result is a density of one to five chips per cubic inch. The Section 357 Advanced Technology work under Earle Bunker is directed toward this basic problem of making interconnections smaller, without loss of reliability and still maintain a repair and modification capability.

Originally, the chips were mounted in hermetically sealed ¼ inch square flat containers (flatpacks) with 10 to 14 flat leads extended so external connections could be made. A breakthrough in flatpack interconnection was achieved in the "stick" concept, originally invented at JPL by Len Katzin, and now in general commercial use. Developments in fine wire welding technology in the Microjoining Laboratory by Ray Jorgensen made it possible to achieve a reliable interconnection with welding rather than soldering of solid wire, for both stick and "cordwood" modules.

A further reduction in size can be achieved by printing the conductor pattern rather than the individual routing of wires. Called the "thick film" process, a conductor pattern is drawn up, photographically reduced and a "silk" screen (actually stainless steel) pattern made. A paste is forced through the voids onto a thin ceramic plate which is then passed through a furnace which melts and fuses the paste into a conducting pattern. In a similar manner, resistors and capacitors can be fired on the same ceramic substrate. Transistor and integrated circuit chips, without the flatpack cases, are then bonded to conducting pads, forming a complete circuit much smaller than the stick approach. The advantages of chip replacement and minor wiring changes are present both in the stick and thick film configurations.

Packaging also has other connotations in the advanced



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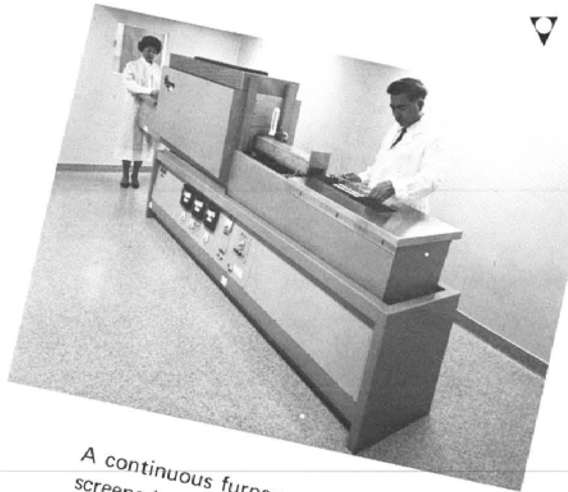
Gloria Hoelscher screening a conductor pattern on the substrates in the Hybrid Microelectronic Facility.



A continuous furnace is required to fuse the screened-on patterns to the substrate. Marge Bickler places the substrates on the belt while John Rice inspects the finished product.

development work of the section. High voltages, always of concern, came to the forefront after the Ranger VI TV cameras refused to function the last ten minutes of a perfect flight. Analysis of data afterward seemed to indicate the TV high voltage supplies inadvertently and unexplainably came on during passage through the region where the voltage breakdown strength of air is a minimum; around 110,000 feet of altitude. Here voltages as low as 270 volts may cause corona or arc-over. In addition, it has been recently estimated that the atmospheric pressure at the surface of Mars is equivalent to this same altitude of lowest breakdown strength on earth. Therefore, any Mars Lander must be designed to operate without voltage breakdown. Since there may be other gases on Mars which would reduce this 270 volt minimum even further, the ultimate test would require the high voltage subsystems to be dunked in salt water while operating.

Encapsulation or potting (putting the electronic modules in a mold and filling up with plastic) is one solution to the high voltage problem. But many times in packaging, one problem is solved only to find others introduced.

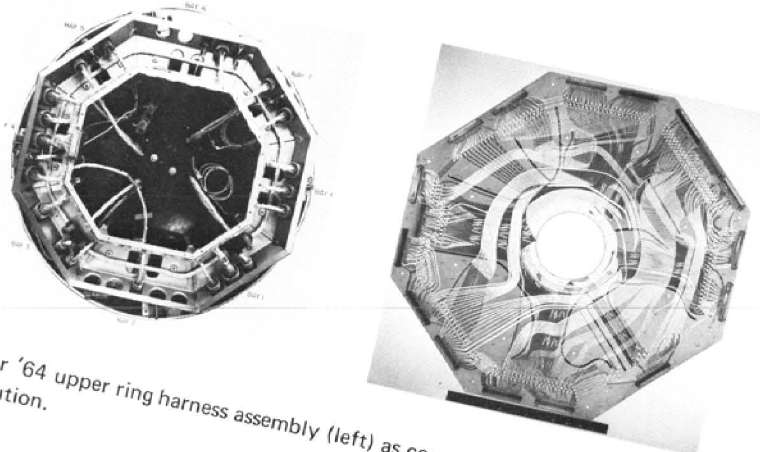
As the temperature is decreased, many plastic encapsulation materials contract much more rapidly than the embedded electronic components. At -40°F one of the most popular materials subjected the electronic components to a crushing pressure of more than 3000 pounds per square inch; or putting it another way, 200 times sea level air pressure, which damaged some components. Extensive measurements of the pressures generated by plastic materials have been made using the conventional mercury thermometer, which makes a good inexpensive pressure gauge. Another problem is that many plastic materials outgas, or give off vapors under vacuum which may result in a radical change in properties, coating of adjacent lenses or interference with delicate mechanisms on the spacecraft during the mission.

The CSAD Lander, designed to be dropped on Mars from a passing Mariner type spacecraft, had encapsulated cavity antennas so the delicate internal elements would survive the high landing jolt. In addition to all the above requirements for plastic encapsulating materials, a few more were added; such as high crushing strength and suitable electrical characteristics at microwave frequencies.

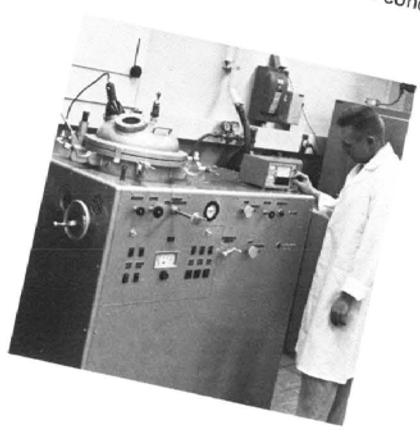
Interconnection of the electronic subsystems of the Mariner '64 was achieved by a large printed conductor harness which resulted in a significant weight saving over the conventional wire cable harness-trough.

Packaging work, like woman's work, "is never done." There is always something new over the horizon.

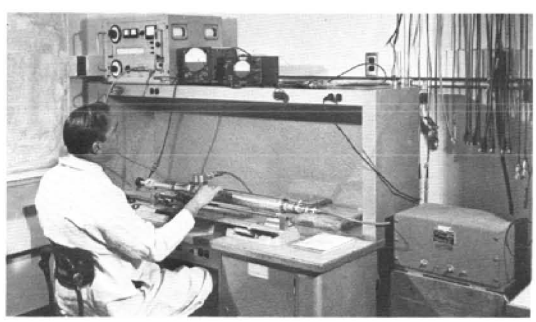
—Earle R. Bunker, Jr.



Mariner '64 upper ring harness assembly (left) as compared to printed conductor substitution.



Tom Hailey processing an experimental plastics sample in the plastics laboratory.



Ron Marzek measuring the characteristics of plastic foam for antenna encapsulation.